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MASSACHUSETTS COASTAL COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM MAY-NOVEMBER, 1996

Bruce T. Estrella
and
Robert P. Glenn

COMMONWEALTH OF MASSACHUSETTS
Division of Marine Fisheries
Philip G. Coates, Director

Department of Fisheries, Wildlife and
Environmental Law Enforcement
John C. Phillips, Commissioner

Executive Office of Environmental Affairs
Trudy Coxe, Secretary

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ABSTRACT

This is the Massachusetts Division of Marine Fisheries sixteenth annual assessment of the status of the American lobster resource in Massachusetts coastal waters. During the period of May through November, 1996, seventy-seven sampling trips were made aboard commercial lobster vessels. A total of 38,115 lobster was sampled from 15,380 trap hauls. The catch rate of marketable lobster, 0.792 lobster per trap, was 11% lower than the 1995 index, 0.893. The proportion of females ovigerous, 15.4%, was higher than in the previous year (14.1%). The coast-wide fishing mortality estimate, 1.29, was similar to the 1995 index of 1.32. Exploitation rate, 0.66, mean carapace length of marketable lobster, 89.2 mm, and mean size of egg-bearing females, 86.7 mm, were relatively unchanged. The cull rate, 22%, fluctuated downward to 17.1%. Less than 1% of the lobster sampled from traps were dead.

An index of pre-recruit abundance was created using data from our sea sampling database. The catch rate of lobster in the pre-recruit size class provided the basis of the index. The index was calculated from a multiple regression of log transformed catch rates with the following factors: month, year, lobsterman. The back-transformed regression coefficient associated with the factor "year", adjusted for the effects of the other analyzed factors, provided the index of pre-recruit abundance. The relationship between the index and Massachusetts territorial waters catch in the following year was modelled using a power function. The resulting equation was used to calculate predicted landings which differed from the actual landings for the years 1981-1996 by 0.09 to 14.1% with a mean difference of 7.2%.

A time series of data from our bottom water temperature monitoring program is presented for seven locations in Buzzards Bay, Cape Cod, and Massachusetts Bay.

INTRODUCTION

This is the Massachusetts Division of Marine Fisheries (DMF) sixteenth annual assessment of the status of the American lobster resource in Massachusetts coastal waters. Since the lobster resource supports the most economically important single-species fishery in Massachusetts coastal waters, a long-term coastwide lobster monitoring program yielding biological and catch per unit effort data was devised and initiated in Massachusetts in May, 1981. A sea sampling/survey design was chosen by which both catch per unit effort and biological data could be collected temporally and areally with sufficient precision for stock assessments. The objective was to assess variations in population parameters due to environmental factors, fishing pressure, and regulatory changes.

Data collected during the 1996 coastwide commercial lobster trap sampling program are summarized below. Parameter trends occurring during the 1981-1996 study period are presented.

STUDY AREA

The study area is primarily defined by the Massachusetts territorial sea, except where lobstering activities of cooperating commercial lobstermen exceeded territorial boundaries (Figure 1). Territorial waters total 5,322 sq km (2,055 sq n mi), of which an estimated 60% is considered major lobster habitat. Six sampling regions, Cape Ann, Beverly-Salem, Boston Harbor, Cape Cod Bay, outer Cape Cod, and Buzzards Bay, were chosen for coverage of the major lobstering regions of the state. For convenience, these regions are depicted in Figure 1 as generalized hatch-marked areas wherein lobster gear sampled may be discontinuously distributed.

SAMPLING PROCEDURE

Sampling of coastal waters was accomplished by monitoring catches during the normal lobstering operations of volunteer commercial lobstermen in each designated region. Multiple lobstering operations were observed to reduce bias from varying degrees of lobstering skill and to enhance areal coverage. Pot-sampling trips were day trips, conducted a minimum of once per month per region during the major lobstering season, May-November.

Utilizing portable cassette tape recorders, sea samplers recorded carapace length (to the nearest mm); sex; and condition, including the degree of shell hardness, culls and other shell damage, external gross pathology, mortality, and presence of extruded ova on females (ovigerous). Catch in number of lobster, number of trap hauls, set-over-days, trap and bait type were also recorded. Trap locations were recorded from LORAN and plotted on nautical charts. Depth information was then acquired from the charts as a coast-wide standard to avoid variability from tidal fluctuations.

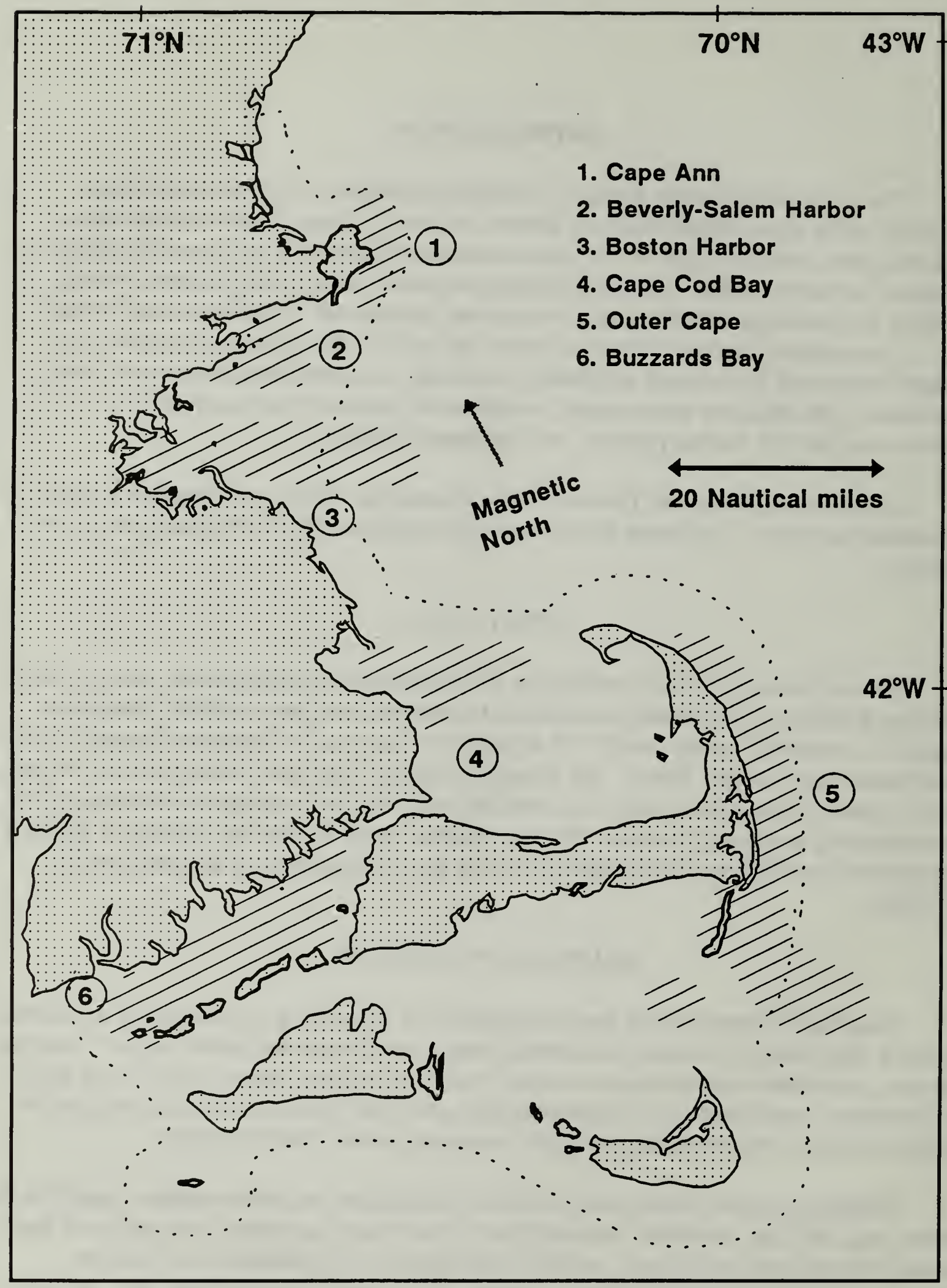

Figure 1. Map of Massachusetts with six sampling regions (hatch-marked) and territorial sea boundary (dotted line) indicated.

ANALYTICAL PROCEDURES

Data were computer coded and keypunched with a microcomputer data entry program. The data base was subsequently transferred for analysis to the Massachusetts Executive Office of Environmental Affairs' (EOEA) Digital Equipment Corporation VAX-11/780 computer system. A computer auditing process was used to uncover keypunch and recording errors and statistical analyses were performed with SPSS (Nie 1983) statistical sub-programs.

Because parameter means exhibit significant regional and monthly variation, an areal and temporal data weighting scheme was incorporated into analytical software. As a result, each month's data contribute equally to regional parameter means which are weighted by area in square nautical miles to generate coastwide means.

Unless specified otherwise, the terms "legal" or "legal sized" lobster include all lobster in the carapace length category $\geq$ 82.6 mm. The marketable segment of this category, which excludes ovigerous females, is analyzed separately and referred to as "marketable lobster". The sublegal length category includes all lobster $<$ 82.6 mm.

The catch rates of marketable lobster are expressed as CTH'_3. This is catch per trap haul standardized to 3 set-over-days (Estrella and McKiernan 1989).

Estimates of total instantaneous mortality (Z) and total annual mortality ($A=1-e^{-Z}$) were computed by two methods which produce extremes in the possible range of estimates. The method of Gulland (1969) requires computation of the regression line slope of natural log transformed numbers at estimated age (15% molt groups, 14% for Buzzards Bay, were derived from tagging data). Beverton and Holt's (1956) process employs von Bertalanffy Growth Equation parameters (from Fair 1977) and mean and minimum length of exploitable sizes.

Estimates of fishing mortality (F) were calculated with cohort analysis (Pope 1972, Jones 1974). Rates of exploitation were calculated with the equation $u=FA/Z$, where F= fishing mortality, A= total annual mortality, and Z= total instantaneous mortality.

Lobster landings data were derived from lobstermen's catch reports which are compiled annually by the DMF Commercial Fisheries Statistics Project.

Since current management strategy stresses uniform coastwide regulations, all data are grouped for a coastwide analysis. However, the uniqueness of the Massachusetts coastline, its role as a temperature barrier which profoundly affects many marine species (Colton 1964), and the influence of offshore lobster stocks on the inshore resource mandate a regional data treatment as well.

RESULTS AND DISCUSSION

Commercial Lobster Sampling

During the period of May through November, 1996, seventy-seven sampling trips were made aboard commercial lobster vessels in Massachusetts coastal waters. A total of 38,115 lobster was sampled from 15,380 trap hauls.

The 1996 coastwide mean catch per unit effort index (CTH'_3), 0.792 marketable lobster per trap, was 11% lower than the 1995 index, 0.893 (Appendix Table 1). Total Massachusetts commercial landings, 15,330,375 lbs, decreased by 3.8% from 1995. Landings from territorial waters, 9,104,949 lbs, decreased by 9.7%. Landings and catch rate trends are depicted in Figure 2. The coastwide mean catch rates of sublegal lobster decreased by 16% (CTHSOD) and 9% (CTHAUL) between 1995 and 1996 and were the lowest in the time series (Appendix Tables 2 and 3).

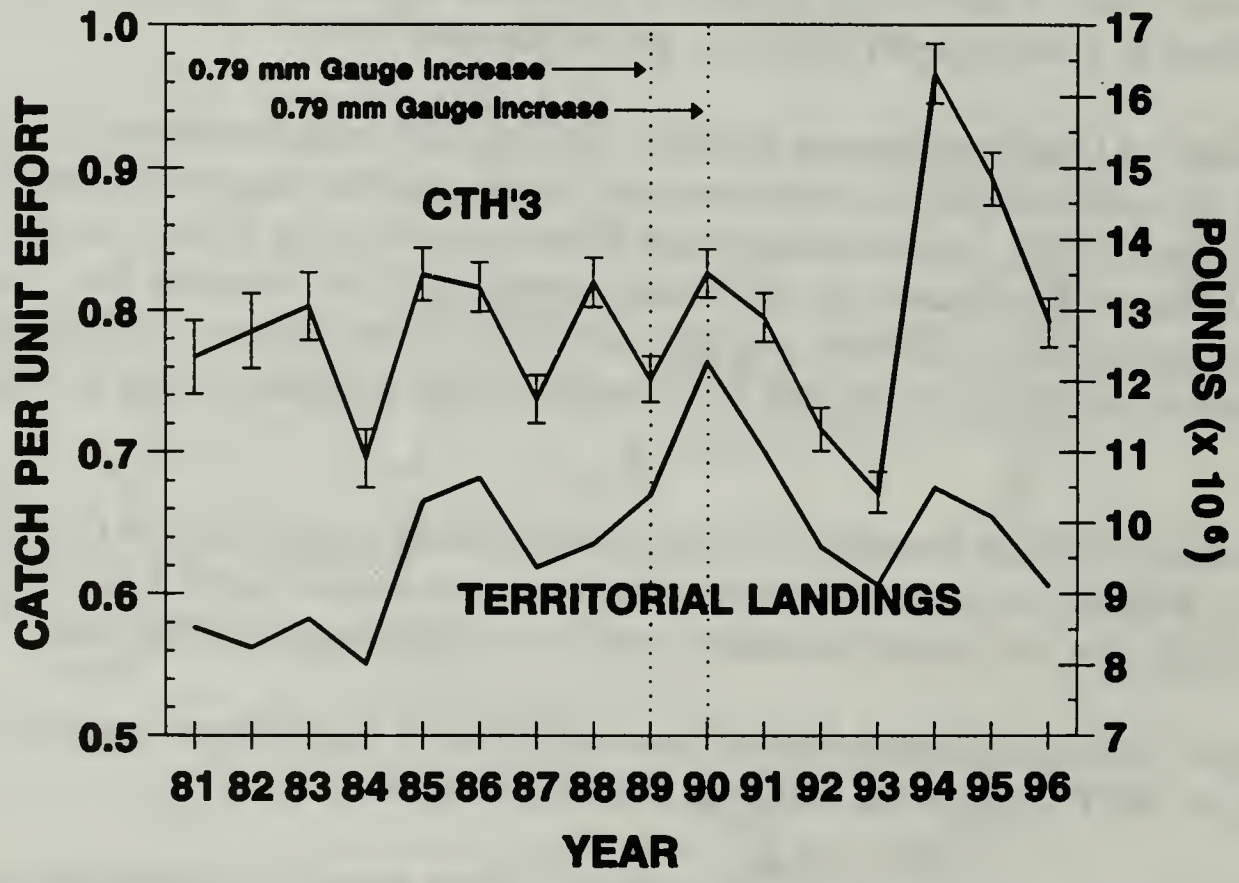

Figure 2. Catch per unit effort of marketable American lobster from commercial trap sampling and Massachusetts lobster landings from territorial waters, 1981 -1996.

Of all females sampled during 1996, 15.4% were ovigerous compared to 14.1% in 1995 (Appendix Table 4). Trends in CPUE of ovigerous females also fluctuated upward and are depicted in Figure 3 (Appendix Tables 4-6).

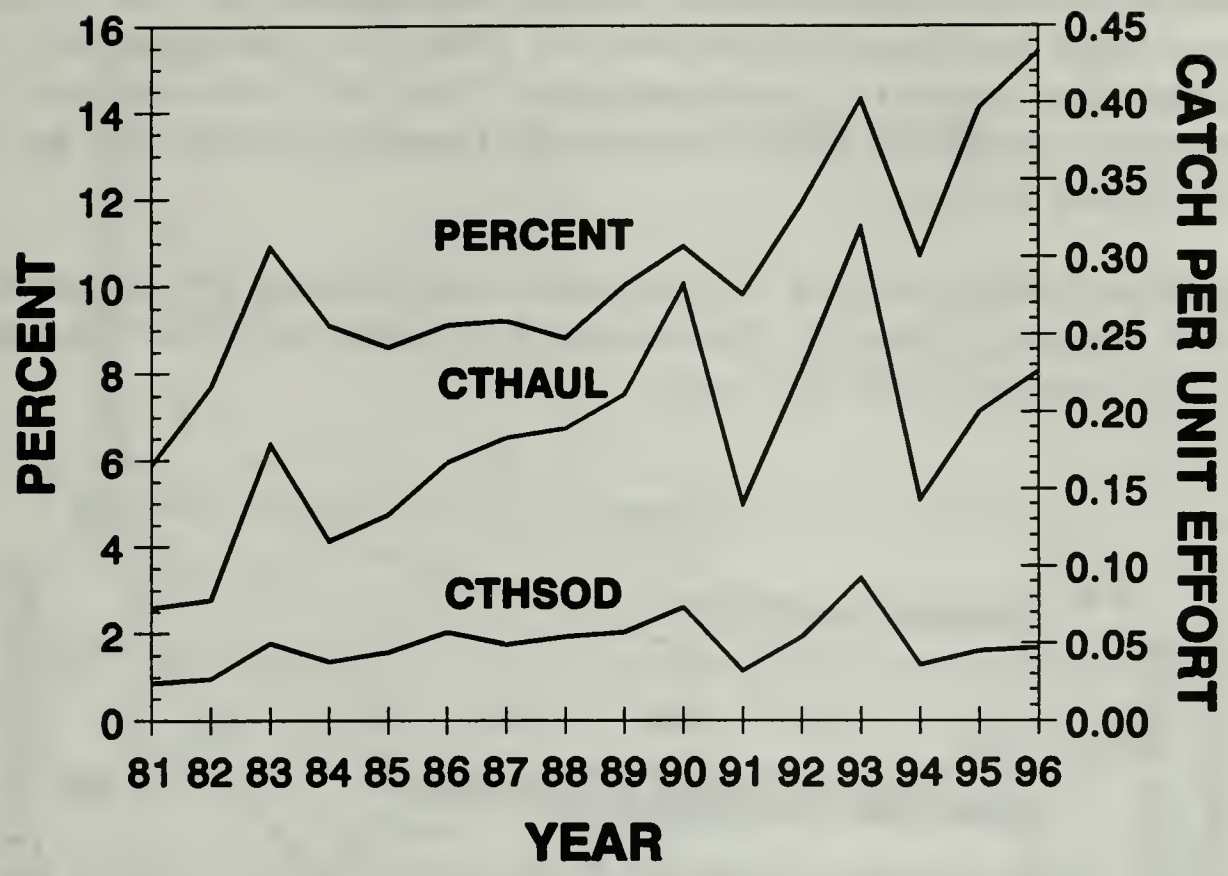

Figure 3. Relative abundance of ovigerous female American lobster in percent total females and catch per effort, Massachusetts coastal waters, 1981 - 1996.

Approximately 91% of the legal catch in our inshore regions (Cape Ann south through Cape Cod Bay and Buzzards Bay) was comprised of new recruits (83 mm-94 mm CL), i.e., lobster which recruited to the legal size range during their most recent molt (Appendix Table 7). This index of the effect of fishing pressure on the size frequency was similar to 1995. It fluctuated from 55% in 1995 to 54% in 1996 for the primarily offshore migrant lobster sampled east of Cape Cod. Estimates of total mortality (Z) for inshore Gulf of Maine regions (Z = 1.49-2.90, A = 77%-94%) and Buzzards Bay (Z = 2.37-2.84, A = 91%-94%) depict a heavily exploited resource while those for the outer Cape Cod region (Z = 0.66-0.73, A = 49%-52%) indicate that a lower level of fishing pressure was exerted on this lobster group (Appendix Tables 8a and 8b).

Estimates of instantaneous fishing mortality (F), the proportion of all deaths which are attributed to fishing, ranged from 0.59 off outer Cape Cod to 1.98 in Buzzards Bay (Appendix Table 9). Exploitation rates (*u*), i.e. the fraction of the population that is removed by fishing, were unchanged from 1995 data (Appendix Table 10).

The relationship between fishing mortality, rate of exploitation, and mean lobster size is depicted in Figure 4. Carapace length exhibited a downward trend as fishing mortality and exploitation rates increased through 1987. Thereafter, increases in mean carapace length of

0.7 mm occurred in 1988 (mean size = 88.2 mm) and 1989 (mean size = 88.9 mm, Appendix Table 11) which reflected the similar numerical change in the minimum legal size during those years. Carapace length then fluctuated downward until 1994-1996. Fishing mortality rates for all regions combined edged upward to a time-series high of 1.48 in 1993, then declined in 1994-1996 along with exploitation rates. The relative change in size frequency between 1995 and 1996 is depicted by the overlay in Figure 5.

Sublegal sized lobster averaged 78.2 mm carapace length during 1996 compared to 77.8 mm during 1995 (Appendix Table 12). The mean size of all ovigerous females was similar between 1995 (86.6 mm) and 1996 (86.7 mm).

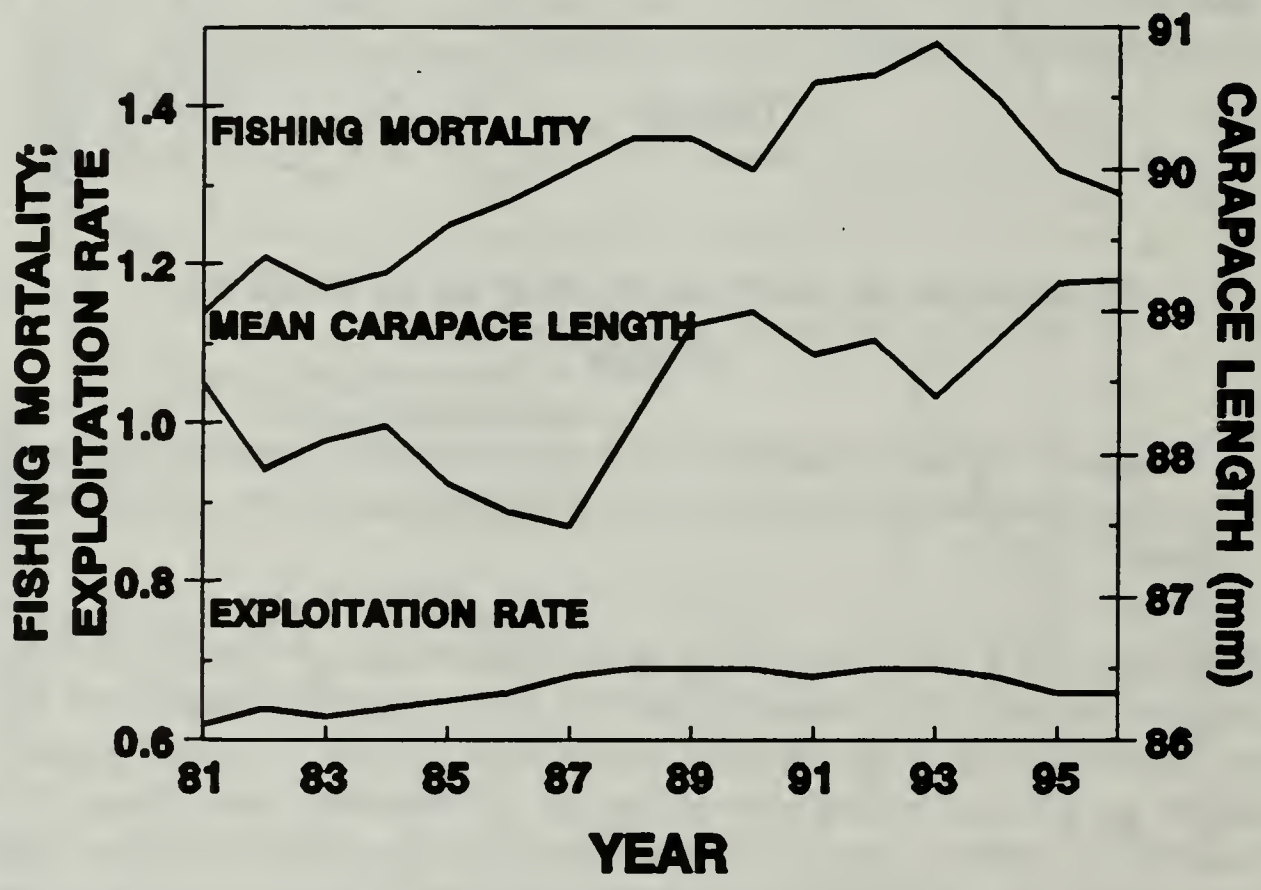

Figure 4. Relationship between exploitation rate, fishing mortality, and mean carapace length of marketable American lobster, Massachusetts coastal waters, 1981 - 1996.

The percentage of culls (lobster with one or both claws missing or regenerating) among all lobster sampled declined from 22.0% in 1995 to 17.1% in 1996 (Appendix Table 14). The cull rates for legal and marketable size groups also declined between years (Appendix Tables 15-17).

The coastwide incidence of lobster found dead in traps was 0.18%. This was similar to that of the previous year (Appendix Table 18) and is acceptably low.

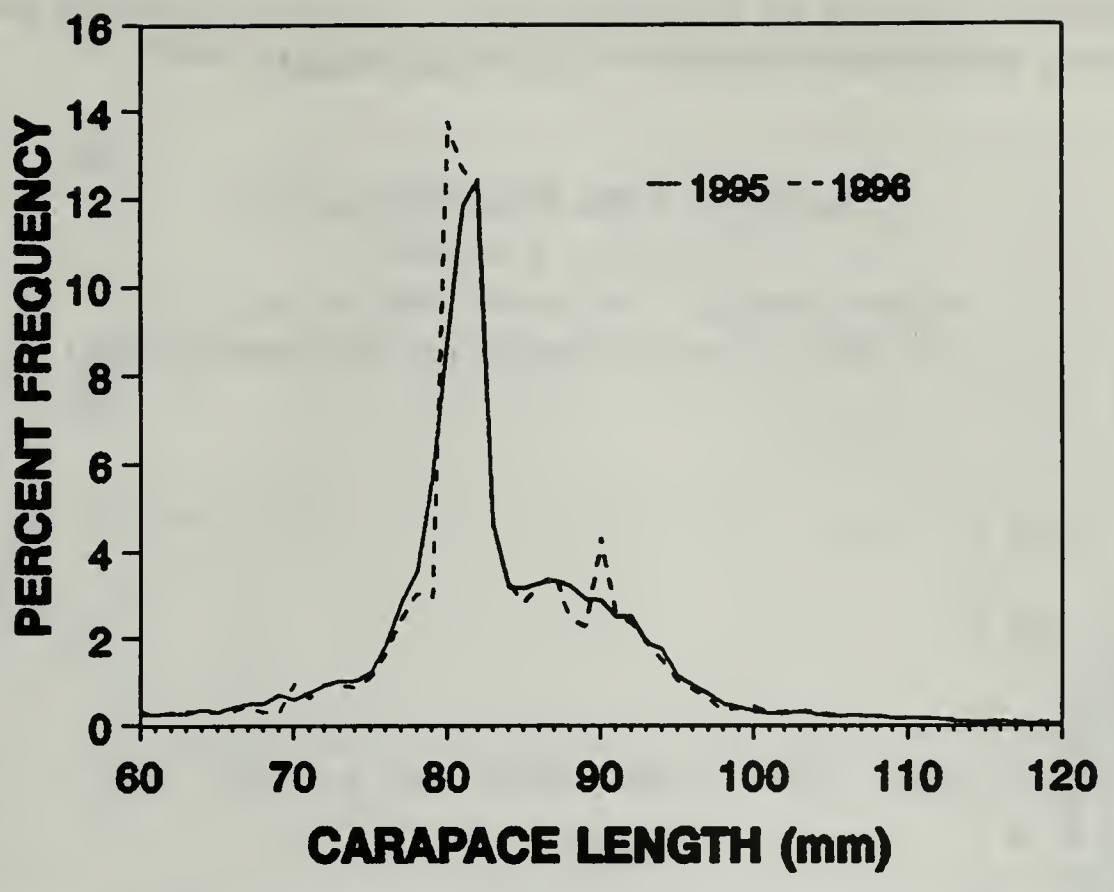

Figure 5. Length frequencies of trap-caught American lobster, Massachusetts coastal waters, 1995 - 1996.

Index of Pre-Recruit Abundance

We created an index of abundance for pre-recruit lobster with data from our sea sampling program. The catch rate (number caught per trap haul) of lobster in the pre-recruit size class provided the basis of the index. The pre-recruit size range changed with increases in minimum legal size (68-80 mm carapace length for the years 1981-1987; 69-81 mm for 1988; and 70-82 mm for 1989 and later). The index was calculated from a multiple regression of logarithmically transformed catch rates with the following factors: month, year, lobsterman. Other factors including soak time, bait, and trap type were incorporated in the preliminary regressions but failed to improve the fit and so they were excluded from the model. The back-transformed regression coefficients associated with the factor "year", adjusted for the effects of month and lobsterman, provide the index of pre-recruit abundance (IPA). This approach which uses regression/ANOVA modelling in the standardization of catch rates has been used successfully to create indices of juvenile abundance in the Western Australia rock lobster (*Panulirus cygnus*) fishery (Caputi and Brown, 1986).

The relationship between the IPA and territorial catch in the following year (Figure 6) was modelled using a power function resulting in the following equation:

$$\mathbf{Catch}_{t+1} = 9{,}866{,}936.715(\mathbf{IPA}_t)^{0.7734}$$

$r^2=0.410$; $p=0.0001$

where $\mathbf{Catch}_{t+1}$ = territorial catch in year t+1

$\mathbf{IPA}_t$ = index of pre-recruit abundance in year t

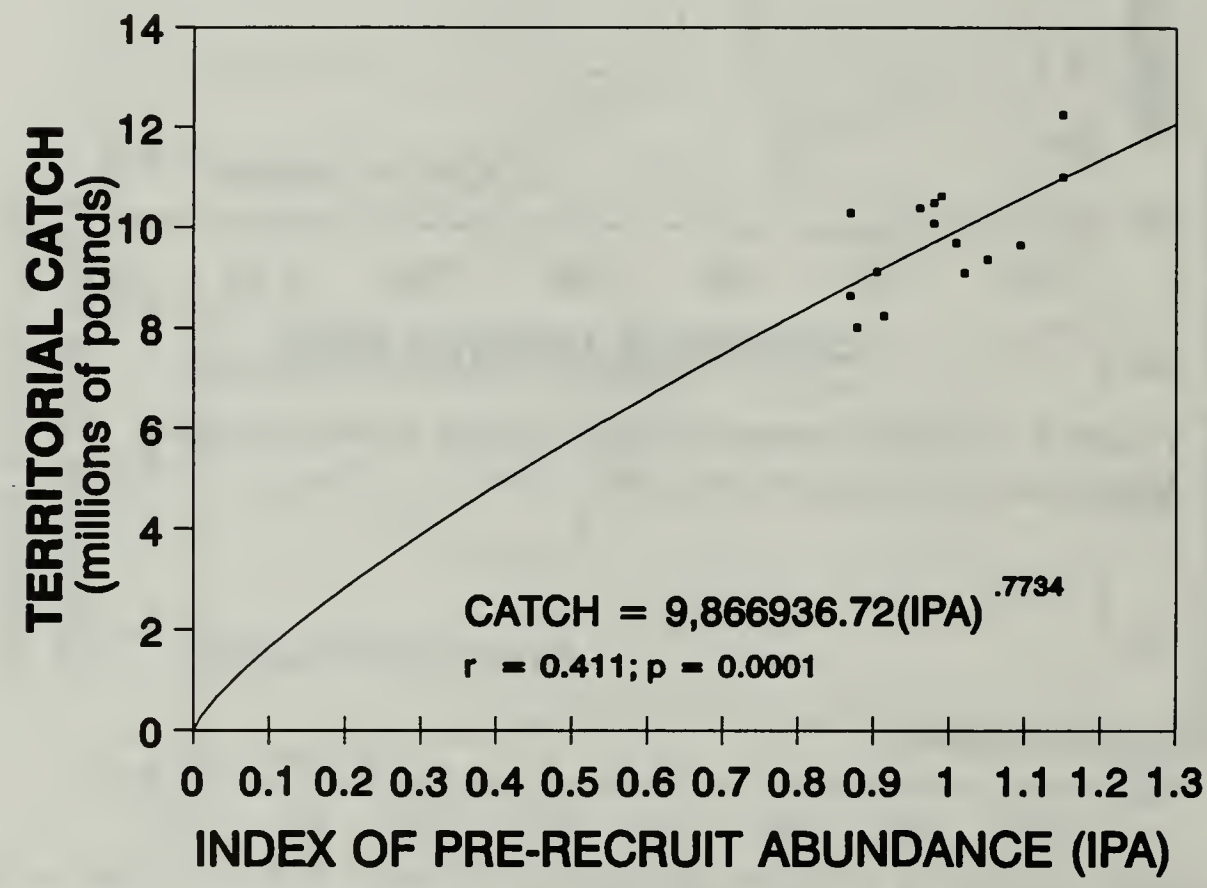

Figure 6. Relationship between the index of pre-recruit abundance and Massachusetts territorial catch one year later.

This equation was used to predict territorial landings. The relationship between predicted territorial landings and actual territorial landings is shown in Figure 7. The predicted values differed from the actual values by 0.09 to 14.1% with a mean difference of 7.2%.

The relatively tight fit between predicted and actual landings ($r=0.65$, $p=0.009$) indicates the model provides modest predictive power for territorial landings. The fit improves in the years after 1987, which may relate to improved catch reporting. The model predicts a slight increase in territorial landings for 1997 to 9,943,543 lbs.

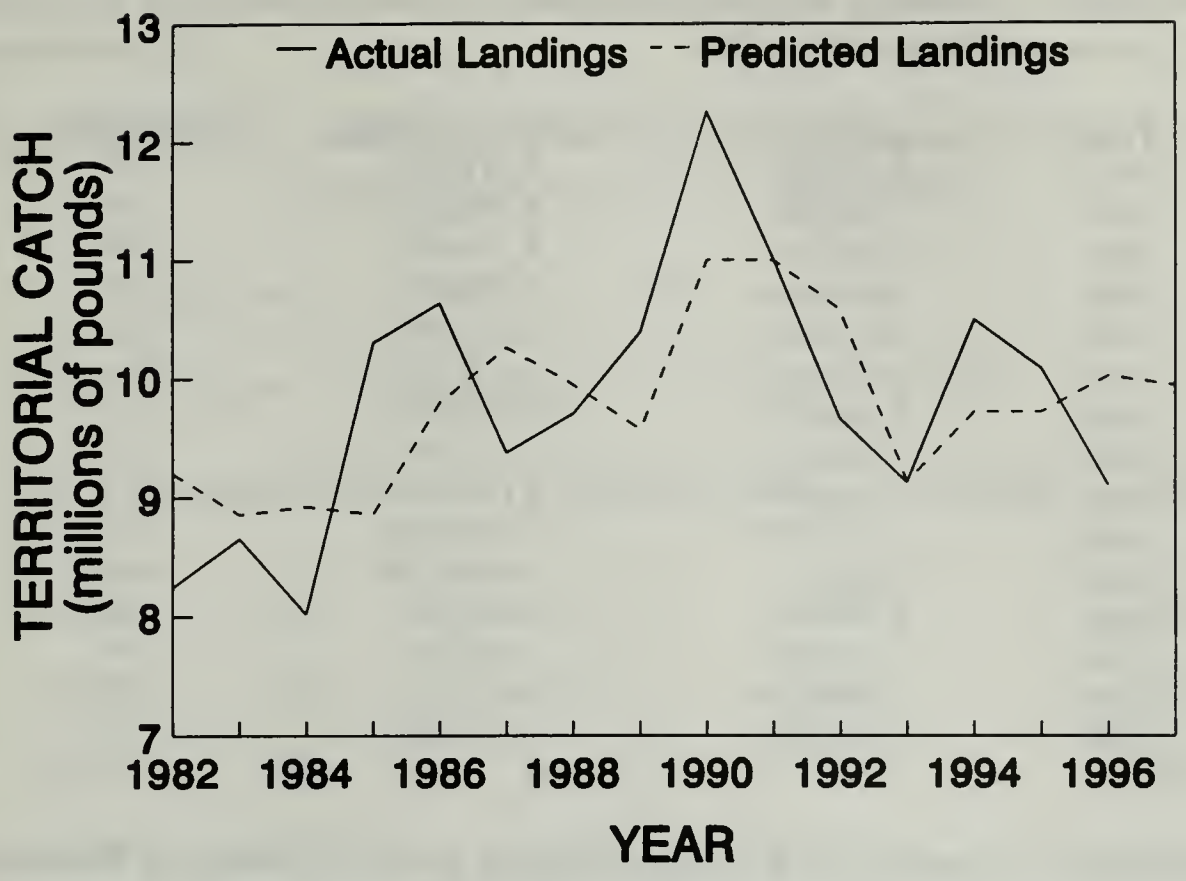

Figure 7. Relationship between predicted landings based on the pre-recruit abundance index and actual territorial landings.

Predicted landings calculations are based solely on the regression equation describing the relationship between the index of pre-recruit abundance in $year_t$ and territorial landings in $year_{t+1}$ for the last year in the time series. Each time new annual data points are added to the database the index of pre-recruit abundance is re-calculated and changes. This causes different predicted annual landings estimates every year that the model is re-run. In order to evaluate the historical predictive power of the model it is therefore necessary to look at past model results during each of the time series years. Table 1 lists the calculated predicted values which differed from actual values by 0.15 to 14.96% with a mean difference of 5.2%. Actual territorial landings and predicted landings are well correlated $r = 0.804$, $p = 0.0003$. As new data are added to the time series each year the variance in predicted landings should decrease and the relationship between actual and predicted landings should improve. This will increase the predictive power of the model.

This model is simplistic in that it does not consider all the sources of variation such as annual temperature fluctuations, fishing effort, and regional differences. An improvement in fit could probably be gained by conducting the analyses on a regional basis but a predictive index with statewide application is more desirable.

Table 1. Landings and predicted landings based on the pre-recruit abundance index.

Year	Landings	Predicted Landings	% Difference
1982	8,244,805	8,217,142	0.34
1983	8,654,914	8,528,013	1.47
1984	8,018,727	8,319,486	3.74
1985	10,303,800	8,762,677	14.96
1986	10,634,200	9,472,354	10.93
1987	9,371,224	9,450,290	0.84
1988	9,700,058	9,337,462	3.74
1989	10,391,100	9,661,041	7.03
1990	12,260,800	11,458,404	6.54
1991	11,011,700	11,316,835	2.77
1992	9,658,545	10,436,168	8.05
1993	9,124,451	9,012,806	1.22
1994	10,498,316	9,581,282	8.74
1995	10,086,601	10,101,313	0.15
1996	9,102,566	9,757,318	7.19

In an attempt to improve the fit of this predictive model the effects of three additional variables were assessed with multiple regression analysis. These variables were; LNTRAP: the natural log of the total number of traps reported fished inside territorial waters, LNTEMP: the natural log of the annual mean surface temperature of Boston Harbor, and LNTEMP6: (also LNTEMP7 and LNTEMP8) the natural log of the annual mean surface temperature of Boston Harbor lagged 6, 7 and 8 years. Analyses were conducted through 1994 when Boston Harbor surface temperature time series, provided by NOAA/National Ocean Services, was terminated. The results of the multiple regression changed the r-squared for the relationship between landings and the IPA from a base value of 0.426 to an adjusted r-square (adjusted r-square accounts for the effects of auto-correlation) ranging from 0.487 for LNTEMP6 to 0.57 for LNTEMP8 (see Table 2 below), and the mean percent difference between actual and predicted landings dropped from 7.2% to a range of 5.97% for LNTEMP6 to 4.41% for LNTEMP8.

To determine if the changes in the r-square value were significant the model was re-run using a stepwise multiple regression technique. This technique adds independent variables to the model one at a time, in all possible combinations, and calculates the proportion of the variance of the dependent variable explained by the independent variable. Independent variables are added to the model only if they account for a significant proportion ($P < 0.05$) of the variance associated with the dependent variable (landings). At the $P < 0.05$ level only the variable IPA accounts for a significant proportion (CHANGE IN $R^2 = 0.426$, $P = 0.011$) of the variance associated with landings. The proportion of the variance accounted for (CHANGE IN R^2), the associated probability (F-PROB TO ENTER) for each independent variable, and F-probability of the resulting predictive equation (F-PROB EQUATION) are listed in the tables below.

Table 2. Results of multiple regression and stepwise multiple regression incorporating three different temperature lags.

Model equation: Landings=355065.3 + 1.7389(IPA) + 1.3344(#TRAPS) + 0.4190(TEMP LAG 6) + 1.5959(TEMP)

Adjusted R^2 = 0.487, p = 0.021

Predicted Landings Mean % Difference = 5.97%

VARIABLES EQUATION	R^2	CHANGE IN R^2	F-PROB TO ENTER	DECISION	F-PROB
IPA	0.426	0.426	0.011	ACCEPT*	0.011
LNTRAP	0.465**	0.039	0.113	REJECT*	0.127
LNTEMP6	0.461**	-0.004	0.490	REJECT*	0.045
LNTEMP	0.487**	0.026	0.253	REJECT*	0.021

Model equation: Landings=163247.71 + 1.3997(IPA) + 1.3851(#TRAPS) + 0.3609(TEMP LAG 7) + 2.2744(TEMP)

Adjusted R^2 = 0.511, p = 0.03

Predicted Landings Mean % Difference = 5.23%

VARIABLES	R^2	CHANGE IN R^2	F-PROB TO ENTER	DECISION	F-PROB EQUATION
IPA	0.426	0.426	0.011	ACCEPT*	0.011
LNTRAP	0.465**	0.039	0.113	REJECT*	0.013
LNTEMP7	0.492**	0.027	0.238	REJECT*	0.02
LNTEMP	0.511**	0.069	0.268	REJECT*	0.03

Table 2 (cont.)

Model equation: Landings=456546.58 + 1.2885(IPA) + 1.2784(#TRAPS) + 0..2824(TEMP LAG 8) + 3.0124(TEMP)

Adjusted $R^2 = 0.57$, $p = 0.018$

Predicted Landings Mean % Difference = 4.41%

VARIABLES	R^2	CHANGE IN R^2	F-PROB TO ENTER	DECISION	F-PROB EQUATION
IPA	0.426	0.426	0.011	ACCEPT*	0.011
LNTRAP	0.465**	0.039	0.113	REJECT*	0.013
LNTEMP8	0.495**	0.03	0.229	REJECT*	0.02
LNTEMP	0.57**	0.075	0.133	REJECT*	0.018

*Significance values set at conventional level of $P < 0.05$.
**Adjusted R-squared.

The variables LNTRAP (P = 0.113), LNTEMP6 (P = 0.506), and LNTEMP (P = 0.531) were rejected because their f-prob to enter values were not significant.

Improved results were found for the model run with a 7-year temperature lag. LNTEMP7 and the interaction between LNTEMP7 and LNTEMP were more significant than LNTEMP6. However, all variables except for IPA were rejected. In spite of these three variables being non-significant at the $P < 0.05$ level, the relatively low p-values of these variables suggest that the relationship between them and landings is real and not an auto-correlation artifact.

The best model results were obtained when temperature was lagged 8 years (LNTEMP8). The f-prob to enter values for LNTRAP, LNTEMP8, and LNTEMP were not significant, however they were lower than f-probability to enter values from other model runs. Sokal and Rohlf (1969) note that this variable acceptance methodology is heuristic, and that it is legitimate to set the f-prob to enter value at other levels. However, it would be necessary to set the threshold level to $P < 0.49$ to accept these variables for use in the regression model. Because this is far above the conventional significance value ($P = 0.05$), LNTRAP, LNTEMP, LNTEMP7, LNTEMP6, and LNTEMP8 were excluded from the predictive model. It is likely that future refinements to these data would allow for their inclusion. For now the IPA will be used as the sole predictor variable for the model.

Water Temperature Time Series

In 1985, a coastal bottom water temperature monitoring project was initiated. Temperature monitors (RYAN Tempmentor) have been deployed for various lengths of time at several sites in Cape Cod Bay, outside Boston Harbor, and Buzzards Bay (Figure 8). Some of these sites are located on ship wrecks.

The longest time series of bottom temperatures is from Cleveland Light in Buzzards Bay. The last monitor to be deployed was at Rocky Point, off Plymouth. The Rocky Point, Manomet Point, *Endicott*, and *Mars* sites represent the 0-30 ft., 30-60 ft., 61-90 ft., and 91-120 ft. depth strata, respectively, in Cape Cod Bay. The *Romance* (off Boston Harbor), and Buzzards Bay-South sites are located at 70-80 ft. and provide data from the north-south extremes in our series. The Cleveland Light monitor is located in 30 feet of water.

Monitors are retrieved and replaced annually by divers. Although the time series contained data from seven monitors at one point, we currently collect data from only six sites because the monitor at the *Endicott* site was lost and has not been replaced. Figures 9 and 10 present the bottom water temperature at sites in Buzzards Bay and Cape Cod Bay/Massachusetts Bay, respectively. Figure 11 provides a comparison between the annual mean bottom temperature at Cleveland Light, Manomet, *Mars*, and *Romance* and the annual mean surface temperature at Boston and Woods Hole provided by NOAA/NOS.

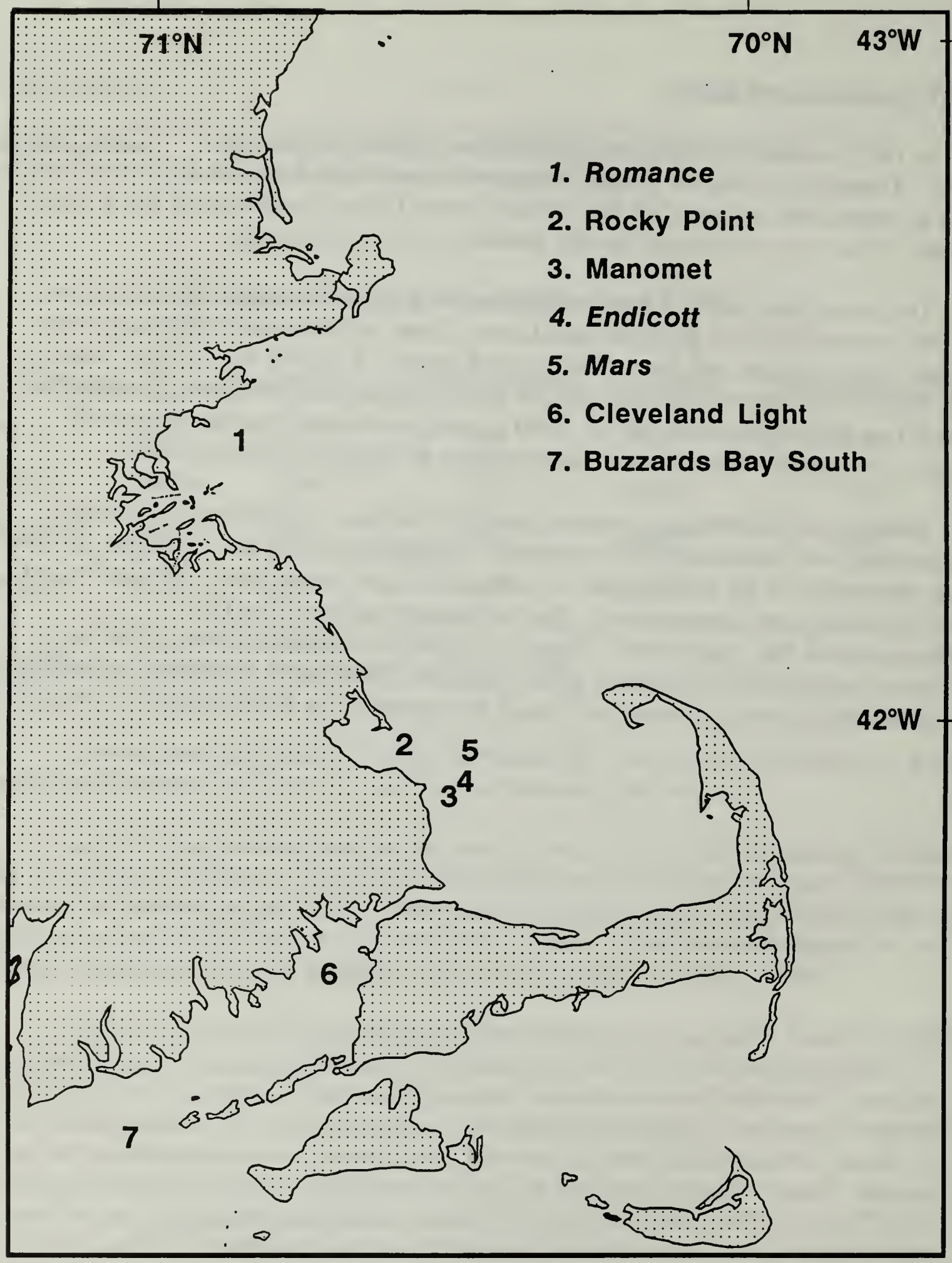

Figure 8. Map of Massachusetts with approximate locations of seven bottom temperature monitors indicated.

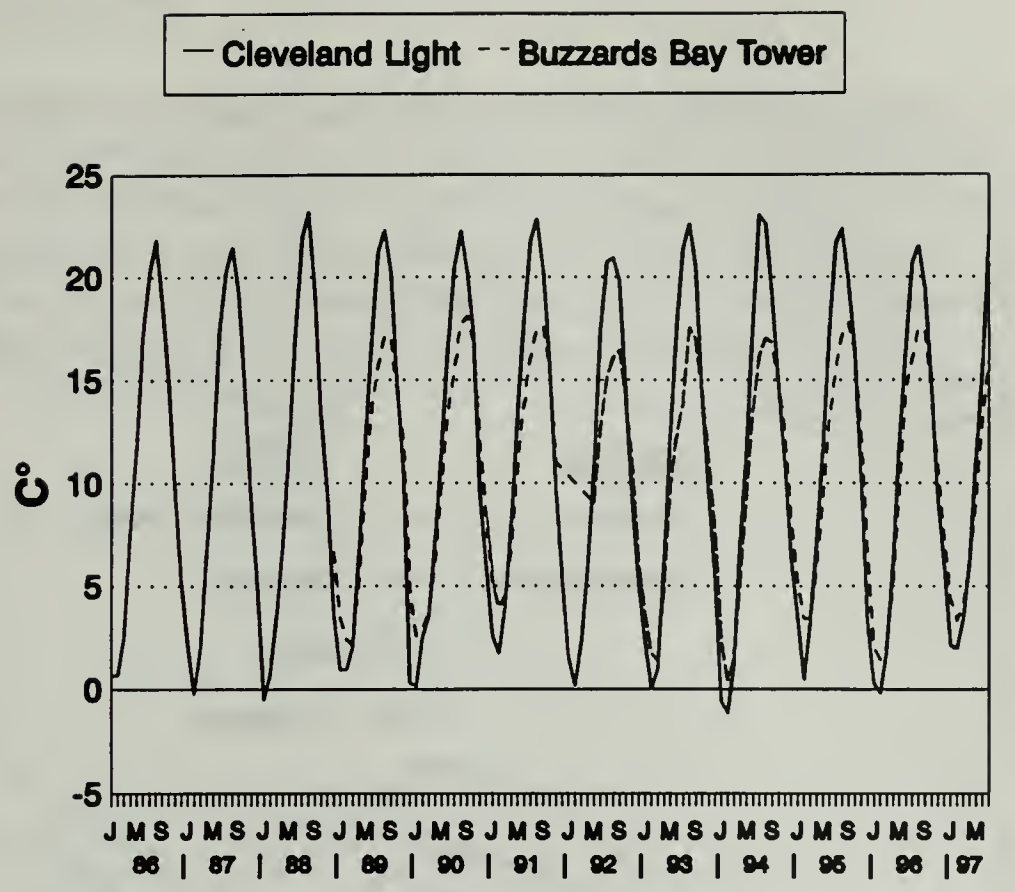

Figure 9. Mean monthly bottom water temperatures at two sites in Buzzards Bay.

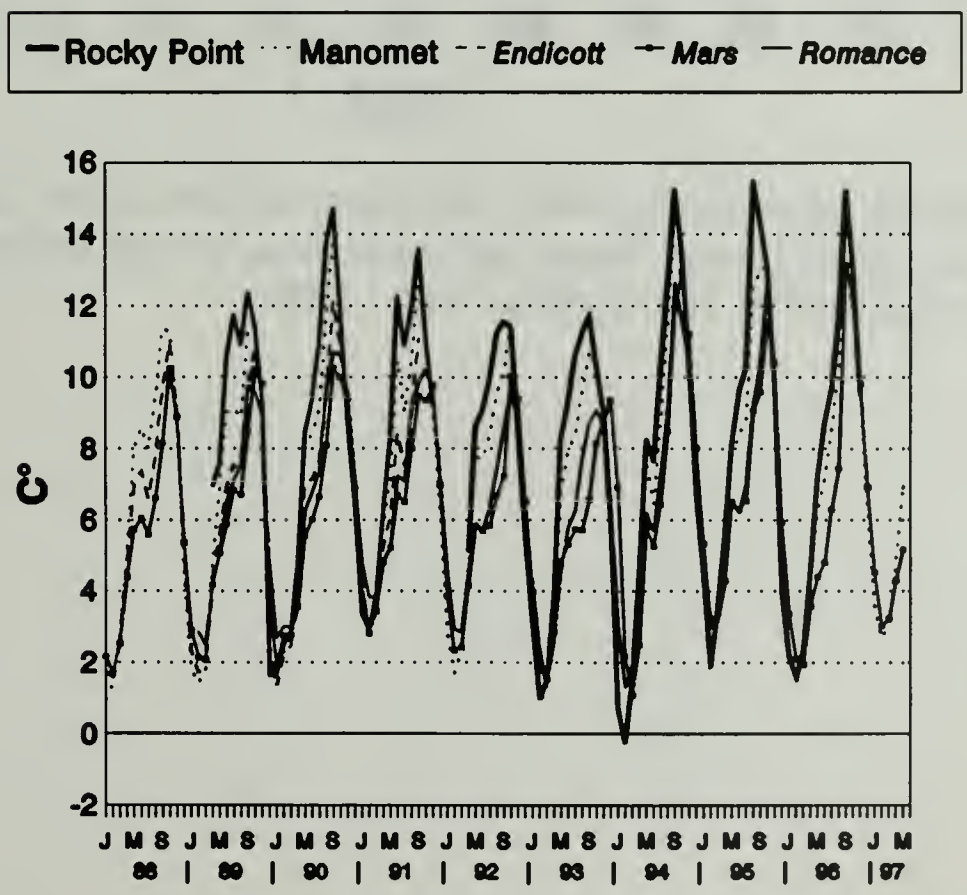

Figure 10. Mean monthly bottom water temperatures at five sites in the Gulf of Maine.

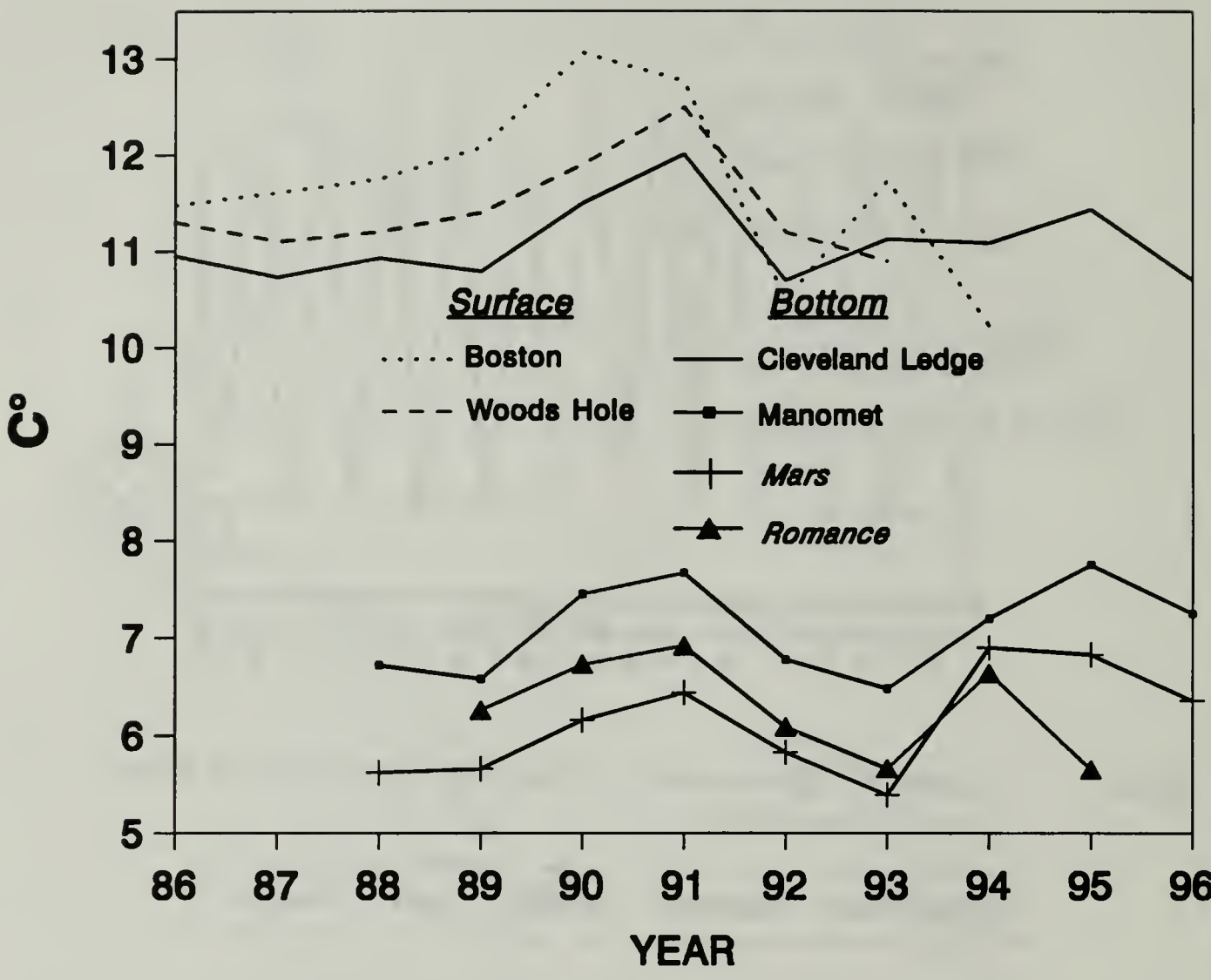

Figure 11. Mean annual bottom water temperatures at four sites monitored by the Coastal Lobster Project and mean annual surface temperature at two sites monitored by NOAA/NOS, 1986 - 1996.

ACKNOWLEDGEMENTS

We are indebted to the many commercial lobstermen whose cooperative spirit and concern for the American lobster resource sustain our lobster monitoring program. Gratitude is also extended to Bill Hoffman, Brad Chase, Rob Johnston, and Kyle Fitzpatrick for data collection, Ann Spires, Kristen Kobialka, and Valerie Hilton for data entry, and James Fair who administered the project and reviewed the manuscript. We also thank Thomas Hoopes for his data entry software design and assistance in data quality control.

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APPENDIX

Table 1. CTH'3, by state and region, for all marketable lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.764	0.785	0.818	0.696	0.825	0.816	0.737	0.820	0.751	0.826	0.725	0.716	0.671	0.966	0.893	0.792
Cape Ann	0.732	0.808	0.624	0.663	0.634	0.699	0.669	0.496	0.721	0.904	0.868	0.724	0.770	1.015	0.979	1.272
Beverly-Salem	0.934	0.898	0.881	0.835	0.663	0.496	0.611	0.661	0.639	0.827	0.586	0.390	0.509	0.898	0.840	0.788
Boston Harbor	—	—	—	1.108	1.254	1.096	1.058	1.057	1.123	1.224	1.160	0.734	0.750	0.725	0.626	0.534
Cape Cod Bay	0.710	0.776	0.680	0.479	0.716	0.822	0.533	0.752	0.539	0.630	0.693	0.567	0.494	1.052	0.906	0.662
Outer Cape Cod	0.808	0.824	0.765	0.598	0.856	0.811	0.937	0.861	0.923	1.219	1.148	1.339	1.021	1.105	1.117	1.027
Buzzards Bay	0.611	0.571	1.110	0.870	0.953	0.907	0.952	1.064	0.934	0.598	0.575	0.817	0.834	0.852	0.893	0.866

Table 2. CTHSOD, by state and region, for all sub-legal American lobster, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.580	0.672	0.718	0.521	0.643	0.780	0.578	0.509	0.695	0.716	0.665	0.465	0.542	0.482	0.416	0.343
Cape Ann	0.067	0.109	0.586	0.450	0.395	0.474	0.417	0.388	0.670	0.589	0.728	0.726	0.447	0.658	0.800	0.573
Beverly-Salem	0.708	0.711	1.263	0.948	0.833	0.801	0.863	0.353	0.780	0.408	0.324	0.411	0.406	0.314	0.334	0.277
Boston Harbor	—	—	—	0.901	1.162	1.138	1.156	0.639	0.966	1.103	0.924	0.839	0.800	0.690	0.782	0.688
Cape Cod Bay	0.710	1.013	0.639	0.322	0.594	0.551	0.371	0.438	0.595	0.727	0.716	0.298	0.436	0.313	0.307	0.217
Outer Cape Cod	0.037	0.024	0.038	0.033	0.035	0.027	0.088	0.064	0.066	0.078	0.077	0.088	0.075	0.045	0.060	0.051
Buzzards Bay	0.787	0.620	0.638	0.785	0.848	1.312	0.871	1.153	1.188	1.236	1.072	0.784	1.156	0.649	0.492	0.540

Table 3. CTHAUL, by state and region, for all sub-legal American lobster, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	1.473	1.401	1.624	1.389	1.705	1.899	1.873	1.736	2.297	2.316	1.996	1.460	1.720	1.389	1.457	1.332
Cape Ann	0.256	0.199	1.044	0.909	1.031	1.126	1.143	1.062	1.765	1.782	1.783	1.661	1.562	1.725	2.323	1.660
Beverly-Salem	1.855	1.713	2.526	2.504	2.567	2.435	3.482	1.862	3.477	1.867	1.563	1.502	1.540	1.717	1.920	1.654
Boston Harbor	—	—	—	2.773	3.038	3.314	3.334	1.959	3.104	3.382	2.451	2.069	2.284	2.189	2.390	2.511
Cape Cod Bay	1.544	1.680	1.345	0.825	1.337	1.512	1.031	1.442	1.742	1.921	2.086	1.065	1.334	1.033	1.102	0.873
Outer Cape Cod	0.233	0.145	0.210	0.189	0.160	0.161	0.324	0.353	0.306	0.453	0.452	0.490	0.474	0.288	0.359	0.372
Buzzards Bay	2.381	1.916	2.316	1.965	2.452	3.118	3.090	3.722	3.984	3.994	3.181	2.602	3.501	2.179	1.599	1.835

Table 4. Percent of females ovigerous, by state and region, for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	8.9	7.7	10.9	9.1	8.6	9.1	9.2	8.8	10.6	10.9	9.8	11.9	14.3	10.7	14.1	15.4
Cape Ann	1.7	3.1	4.4	3.2	4.6	5.0	4.5	3.5	6.3	6.9	4.3	6.7	9.3	4.7	5.3	6.4
Beverly-Salem	1.7	2.8	1.2	0.4	1.9	1.1	1.8	1.5	1.6	1.8	3.2	3.9	5.4	2.3	6.3	6.9
Boston Harbor	—	—	—	1.4	1.2	2.0	1.7	2.0	2.1	2.7	2.8	3.0	4.4	4.7	5.0	6.7
Cape Cod Bay	3.9	3.1	3.7	3.1	3.2	2.1	3.9	2.9	3.0	3.3	5.4	6.8	6.8	7.4	10.2	13.6
Outer Cape Cod	11.1	23.0	30.3	26.8	22.3	28.9	16.9	21.4	27.4	24.5	18.3	27.7	26.8	27.3	34.4	34.6
Buzzards Bay	16.0	16.9	32.5	26.6	25.0	25.3	31.0	27.8	29.2	35.0	28.2	28.8	40.9	22.1	26.0	23.6

Table 5. CTHSOD, by state and region, for all ovigerous female American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.024	0.027	0.050	0.038	0.044	0.057	0.049	0.054	0.057	0.073	0.032	0.054	0.092	0.036	0.045	0.047
Cape Ann	0.002	0.011	0.024	0.015	0.016	0.017	0.016	0.010	0.037	0.035	0.024	0.050	0.038	0.024	0.030	0.031
Beverly-Salem	0.011	0.009	0.008	0.003	0.011	0.004	0.010	0.004	0.009	0.005	0.008	0.014	0.020	0.008	0.017	0.015
Boston Harbor	—	—	—	0.009	0.007	0.015	0.012	0.012	0.010	0.028	0.017	0.017	0.026	0.024	0.028	0.032
Cape Cod Bay	0.020	0.025	0.016	0.009	0.015	0.010	0.012	0.009	0.014	0.017	0.028	0.016	0.023	0.022	0.034	0.035
Outer Cape Cod	0.012	0.028	0.040	0.030	0.038	0.032	0.034	0.030	0.043	0.055	0.038	0.076	0.053	0.046	0.081	0.085
Buzzards Bay	0.079	0.053	0.230	0.183	0.193	0.297	0.234	0.289	0.270	0.349	0.073	0.197	0.446	0.110	0.088	0.098

Table 6. CTHAUL, by state and region, for all ovigerous female American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.073	0.078	0.179	0.116	0.183	0.167	0.183	0.189	0.211	0.282	0.140	0.227	0.319	0.143	0.209	0.226
Cape Ann	0.010	0.016	0.038	0.027	0.039	0.047	0.048	0.031	0.096	0.109	0.056	0.088	0.135	0.064	0.085	0.081
Beverly-Salem	0.025	0.033	0.016	0.006	0.033	0.018	0.036	0.021	0.039	0.023	0.049	0.047	0.067	0.048	0.106	0.103
Boston Harbor	—	—	—	0.030	0.025	0.050	0.037	0.038	0.043	0.075	0.064	0.046	0.081	0.088	0.100	0.124
Cape Cod Bay	0.048	0.048	0.040	0.024	0.040	0.031	0.038	0.034	0.039	0.055	0.091	0.056	0.078	0.075	0.128	0.147
Outer Cape Cod	0.081	0.178	0.242	0.170	0.176	0.225	0.157	0.198	0.258	0.342	0.251	0.453	0.317	0.306	0.514	0.561
Buzzards Bay	0.243	0.139	0.828	0.515	0.555	0.748	0.889	0.929	0.953	1.291	0.359	0.847	1.438	0.383	0.343	0.414

Table 7. Estimated fishing pressure index, by state and region, commercial lobster trap catch survey, Massachusetts coastal water, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	86	87	86	86	88	88	89	90	88	87	90	89	90	88	86	86
Cape Ann	91	92	87	89	87	87	88	90	84	81	90	87	83	86	88	85
Beverly-Salem	89	92	94	88	96	96	97	98	96	95	97	98	96	96	95	95
Boston Harbor	—	—	—	93	94	96	96	96	96	95	96	95	96	95	94	95
Cape Cod Bay	90	93	92	94	93	94	92	94	94	93	91	92	94	90	86	88
Outer Cape Cod	46	43	42	38	48	46	54	57	47	50	54	57	60	60	55	54
Buzzards Bay	98	96	96	94	96	97	97	97	95	94	95	97	97	98	96	95

Table 8A. Total instantaneous (Z)* and total annual (A)** mortality estimates (Gulland, 1969) of American lobster by state and region, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	1.58 *	1.72	1.66	1.66	1.76	1.80	1.90	1.86	1.80	1.76	1.90	1.92	1.86	2.02	1.83	1.79
	79% **	82	81%	81%	83%	84%	85%	84%	83%	83%	85%	85%	84%	87%	84%	83%
Cape Ann	1.65	2.18	1.72	1.92	1.94	2.03	1.85	1.75	1.55	1.39	1.97	1.87	1.51	1.81	1.95	1.90
	81%	89%	82%	85%	86%	87%	84%	83%	79%	75%	86%	85%	78%	84%	86%	85%
Beverly-Salem	1.97	2.15	2.41	2.71	3.64	3.60	3.49	3.31	3.59	2.81	3.49	3.12	2.62	3.34	3.10	2.90
	86%	88%	91%	93%	97%	97%	97%	96%	97%	94%	97%	96%	93%	96%	95%	94%
Boston Harbor	—	—	—	2.52	3.59	2.60	2.77	2.86	2.96	3.00	3.40	3.54	3.26	3.21	2.87	2.65
	—	—	—	92%	97%	93%	94%	94%	95%	95%	97%	97%	96%	96%	94%	93%
Cape Cod Bay	2.53	2.69	2.42	2.52	2.31	2.83	2.26	2.74	2.43	2.46	2.33	2.58	2.60	3.10	2.35	2.09
	92%	93%	91%	92%	90%	94%	90%	94%	91%	91%	90%	92%	93%	95%	90%	88%
Outer Cape Cod	0.43	0.46	0.42	0.33	0.52	0.51	0.80	0.71	0.62	0.63	0.77	0.78	0.87	0.92	0.74	0.73
	35%	37%	34%	28%	41%	40%	55%	51%	46%	47%	54%	54%	58%	60%	52%	52%
Buzzards Bay	3.02	3.00	8.64	3.14	3.55	3.71	3.48	3.18	3.13	2.60	3.50	3.81	3.03	3.58	3.34	2.84
	95%	95%	99%	96%	97%	98%	97%	96%	96%	93%	97%	98%	95%	97%	96%	94%

Table 8B. Total instantaneous (Z)* and total annual (A)** mortality estimates (Beverton and Holt, 1956) of American lobster by state and region, Massachusetts coastal waters, 1981-1996

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	1.35	1.45	1.39	1.41	1.47	1.49	1.54	1.56	1.53	1.50	1.73	1.78	1.79	1.67	1.57	1.54
	74%	**77%	75%	76%	77%	78%	79%	79%	78%	78%	82%	82%	83%	81%	79%	79%
Cape Ann	1.32	1.39	1.35	1.52	1.33	1.32	1.39	1.51	1.27	1.66	1.77	1.57	1.38	1.48	1.62	1.49
	73%	75%	74%	78%	74%	73%	75%	78%	72%	81%	83%	79%	75%	77%	80%	77%
Beverly-Salem	1.59	1.70	1.85	1.78	1.96	1.99	2.16	1.98	2.01	1.83	2.29	2.50	2.23	2.18	2.09	2.11
	80%	82%	84%	83%	86%	86%	88%	86%	87%	84%	90%	92%	89%	89%	88%	88%
Boston Harbor	—	—	—	1.82	1.75	1.92	1.88	1.84	1.94	1.87	2.19	2.14	2.33	2.28	2.09	2.18
	—	—	—	84%	83%	85%	85%	84%	86%	85%	89%	88%	90%	90%	88%	89%
Cape Cod Bay	1.64	1.92	1.72	2.07	1.88	1.92	1.78	1.87	1.97	1.95	1.96	2.01	2.14	1.93	1.65	1.66
	81%	85%	82%	87%	85%	85%	83%	85%	86%	86%	86%	87%	88%	86%	81%	81%
Outer Cape Cod	0.54	0.55	0.53	0.52	0.57	0.55	0.66	0.66	0.62	0.63	0.71	0.72	0.78	0.79	0.72	0.68
	42%	42%	41%	41%	43%	42%	48%	48%	46%	47%	51%	51%	54%	55%	51%	49%
Buzzards Bay	2.97	2.53	2.26	2.21	2.36	2.41	2.36	2.35	2.14	2.27	3.08	2.70	3.11	2.85	2.44	2.37
	95%	92%	90%	89%	91%	91%	91%	94%	88%	90%	95%	93%	96%	94%	91%	91%

Table 9. Instantaneous fishing mortality estimates (F), by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	1.14	1.21	1.17	1.19	1.25	1.28	1.32	1.36	1.36	1.32	1.43	1.44	1.46	1.41	1.32	1.29
Cape Ann	1.33	1.47	1.11	1.33	1.28	1.22	1.30	1.37	1.12	1.04	1.50	1.32	1.14	1.25	1.36	1.28
Beverly-Salem	1.42	1.47	1.64	1.68	1.81	1.93	1.89	2.02	1.95	1.86	2.08	2.16	1.96	1.94	1.88	1.91
Boston Harbor	—	—	—	1.77	1.70	1.80	1.87	1.83	1.94	1.86	2.01	1.97	1.97	1.90	1.85	1.89
Cape Cod Bay	1.53	1.60	1.58	1.73	1.59	1.70	1.56	1.70	1.82	1.72	1.66	1.71	1.85	1.66	1.47	1.44
Outer Cape Cod	0.47	0.48	0.45	0.42	0.47	0.47	0.57	0.53	0.54	0.51	0.59	0.61	0.65	0.68	0.62	0.59
Buzzards Bay	2.32	2.13	1.94	1.80	2.04	2.11	2.08	2.06	1.95	1.97	2.34	2.26	2.39	2.31	2.05	1.98

Table 10. Estimated exploitation rate (u), by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.62	0.64	0.63	0.64	0.65	0.66	0.68	0.69	0.69	0.69	0.68	0.69	0.69	0.68	0.66	0.66
Cape Ann	0.74	0.80	0.61	0.68	0.71	0.67	0.70	0.71	0.63	0.51	0.70	0.67	0.62	0.65	0.67	0.66
Beverly-Salem	0.71	0.71	0.75	0.79	0.79	0.83	0.77	0.88	0.76	0.85	0.82	0.79	0.78	0.79	0.79	0.80
Boston Harbor	—	—	—	0.82	0.81	0.80	0.84	0.84	0.86	0.85	0.82	0.81	0.76	0.75	0.78	0.77
Cape Cod Bay	0.75	0.71	0.75	0.73	0.72	0.75	0.73	0.77	0.79	0.76	0.73	0.74	0.76	0.74	0.72	0.70
Outer Cape Cod	0.37	0.37	0.35	0.33	0.36	0.36	0.41	0.38	0.40	0.38	0.42	0.44	0.45	0.47	0.44	0.43
Buzzards Bay	0.74	0.78	0.77	0.72	0.79	0.80	0.80	0.82	0.80	0.78	0.72	0.78	0.74	0.76	0.76	0.76

Table 11. Mean carapace length (mm), by state and region, for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	88.3	87.9	88.1	88.2	87.8	87.6	87.5	88.2	88.9	89.0	88.7	88.8	88.4	88.8	89.2	89.2
Cape Ann	88.6	88.3	88.3	87.9	88.4	88.3	88.0	88.3	89.3	90.3	88.4	88.8	89.6	89.6	88.7	89.5
Beverly-Salem	87.6	87.0	86.6	86.9	86.2	86.2	85.8	87.1	87.7	88.3	87.5	87.2	87.5	87.8	88.0	87.9
Boston Harbor	—	—	—	86.8	86.9	86.4	86.6	87.5	88.0	88.1	87.8	87.9	87.5	87.5	88.0	87.7
Cape Cod Bay	87.2	86.4	86.9	86.1	86.4	86.3	86.7	87.3	87.7	87.7	88.1	88.2	87.7	88.3	89.2	89.0
Outer Cape Cod	98.2	97.5	97.4	99.7	97.0	96.3	94.6	95.2	96.5	96.1	95.3	95.2	93.8	94.2	94.2	94.9
Buzzards Bay	84.7	85.2	85.7	85.8	85.2	85.3	85.3	86.1	87.4	87.0	86.4	86.9	86.5	86.5	87.4	87.3

Table 12. Mean carapace length (mm), by state and region for all sub-legal American lobster, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	75.8	76.3	76.2	76.1	76.3	76.1	76.1	76.3	77.5	77.6	76.7	76.2	76.9	77.5	77.8	78.2
Cape Ann	78.0	77.7	77.5	77.3	77.6	77.1	75.9	77.0	78.3	78.8	78.7	77.9	78.3	78.0	77.2	77.3
Beverly-Salem	74.3	76.5	74.9	76.1	75.9	74.7	74.7	74.5	76.4	76.1	73.4	73.5	75.1	75.8	76.2	76.8
Boston Harbor	—	—	—	77.1	76.9	76.9	76.5	75.6	76.8	77.4	75.4	74.6	75.3	76.0	77.3	76.9
Cape Cod Bay	76.6	76.4	76.7	75.6	76.1	76.2	75.6	76.9	77.9	77.8	77.4	76.8	76.7	78.6	78.6	79.8
Outer Cape Cod	75.9	76.2	77.1	75.1	76.6	75.9	77.0	77.1	76.8	78.8	78.8	79.0	79.4	78.3	80.0	79.9
Buzzards Bay	75.8	75.5	76.8	76.4	76.1	76.0	76.6	76.3	77.7	77.4	76.6	77.1	78.3	77.6	77.7	77.5

Table 13. Mean carapace length (mm) of all ovigerous female American lobster, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	88.5	87.6	88.0	87.4	87.9	88.1	87.1	87.2	88.5	88.0	86.0	85.5	85.3	86.3	86.6	86.7
Cape Ann	109.0	100.3	94.3	90.5	93.8	95.0	91.6	94.0	100.4	95.1	91.7	91.9	91.0	92.7	93.3	91.5
Beverly-Salem	80.5	84.5	85.8	83.5	85.9	83.5	81.8	83.0	85.2	85.5	83.8	81.6	82.6	83.1	83.3	83.0
Boston Harbor	—	—	—	82.1	84.0	81.3	82.3	83.7	83.0	83.8	82.0	82.0	80.8	80.9	81.5	82.4
Cape Cod Bay	86.4	83.8	85.5	84.4	85.2	86.8	87.0	84.7	86.1	85.0	83.9	84.1	83.0	84.8	85.2	85.7
Outer Cape Cod	109.8	106.1	108.0	107.1	106.9	107.3	102.5	105.2	105.4	104.6	101.9	99.2	100.7	100.0	100.6	99.6
Buzzards Bay	78.1	79.6	81.6	83.0	80.1	79.4	80.2	80.6	81.3	80.8	79.8	79.9	81.0	81.5	81.8	82.6

Table 14. Cull rate (percent), by state and region, for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal water, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	10.0	10.3	10.7	14.8	18.1	20.9	17.0	18.2	19.2	18.6	18.1	18.5	20.2	21.9	22.6	17.1
Cape Ann	10.0	9.8	10.5	11.5	23.9	25.3	20.2	21.2	16.7	16.7	19.7	18.2	19.2	17.1	19.6	18.0
Beverly-Salem	8.3	8.6	10.2	20.9	23.0	30.0	24.1	26.3	28.6	27.3	28.9	22.7	28.3	30.8	25.1	24.6
Boston Harbor	—	—	—	13.3	19.3	19.1	16.9	16.3	13.8	14.7	13.5	17.2	23.4	23.0	22.2	17.8
Cape Cod Bay	11.1	10.7	10.9	15.6	18.3	21.6	16.2	17.4	22.8	20.5	18.9	18.3	18.1	19.4	21.5	16.2
Outer Cape Cod	5.7	11.3	8.9	13.0	13.4	16.1	12.6	15.0	14.0	15.5	13.2	15.7	17.3	20.1	19.0	13.3
Buzzards Bay	13.5	14.7	12.4	12.4	13.4	14.6	15.1	15.6	12.6	13.6	13.9	19.3	20.5	24.0	24.4	15.0

Table 15. Cull rate (percent), by state and region, for all legal-sized American lobster, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	8.3	9.7	9.2	12.7	14.5	17.0	14.2	15.2	14.9	15.4	15.6	17.1	17.4	21.2	20.9	15.1
Cape Ann	10.7	9.6	7.5	10.4	19.4	20.3	18.0	19.3	13.9	13.7	16.8	18.3	16.3	16.5	16.2	14.7
Beverly-Salem	4.3	7.7	7.4	15.5	19.3	22.1	17.1	21.4	18.7	25.6	22.8	19.9	24.6	25.4	18.8	20.2
Boston Harbor	—	—	—	10.1	16.2	15.8	12.9	13.1	9.9	9.9	12.3	14.0	17.5	18.0	20.1	17.3
Cape Cod Bay	9.3	9.3	10.0	13.2	14.5	18.1	15.0	15.6	12.0	16.3	17.8	16.8	16.3	21.7	23.3	16.0
Outer Cape Cod	5.3	10.3	8.1	13.3	12.5	14.9	13.1	14.3	13.3	14.1	12.8	15.3	16.4	19.9	18.3	12.6
Buzzards Bay	16.1	13.2	12.7	12.3	13.8	13.6	15.2	14.1	12.6	12.6	11.5	22.2	18.9	23.5	22.6	12.9

Table 16. Cull rate (percent), by state and region, for marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	8.2	9.9	9.2	13.2	16.2	17.6	14.7	16.8	15.2	15.6	16.1	17.6	17.6	21.9	21.5	15.6
Cape Ann	10.8	9.8	7.3	10.5	20.9	20.7	18.4	19.9	14.0	14.2	16.8	18.1	13.7	16.7	16.0	14.5
Beverly-Salem	4.4	8.0	7.4	15.6	18.5	22.2	17.2	21.3	18.9	23.8	23.1	20.0	24.7	25.5	19.0	20.0
Boston Harbor	---	---	---	10.2	16.2	15.7	12.8	13.1	9.9	9.9	12.4	14.0	17.5	18.0	20.1	17.4
Cape Cod Bay	9.3	9.3	10.0	13.2	15.9	18.2	14.8	15.6	19.1	16.2	17.8	16.7	16.2	22.3	23.3	16.6
Outer Cape Cod	5.3	10.9	8.6	14.8	12.9	16.8	13.2	14.9	13.9	14.6	14.1	16.8	17.3	21.6	20.4	14.0
Buzzards Bay	16.9	13.1	12.3	12.6	15.4	14.1	15.4	14.7	13.0	12.4	11.7	22.5	19.4	23.7	23.0	13.1

Table 17. Cull rate (percent), by state and region, for sub-legal American lobster, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	11.2	11.5	11.6	16.1	20.2	20.3	18.2	19.6	21.1	20.2	19.2	19.3	21.8	22.5	22.9	18.5
Cape Ann	8.0	10.6	12.6	12.2	26.9	28.7	21.5	22.1	17.9	18.3	21.0	18.2	20.9	17.4	21.2	20.6
Beverly-Salem	10.0	9.0	11.2	22.3	24.0	31.8	25.3	28.6	30.8	29.2	31.6	23.5	29.5	33.8	28.2	26.7
Boston Harbor	---	---	---	14.5	20.5	20.0	18.0	18.0	15.2	16.4	13.9	18.3	25.3	24.7	22.8	17.9
Cape Cod Bay	11.9	11.3	11.4	17.0	20.2	23.4	16.8	18.3	24.0	21.8	19.2	19.0	18.8	17.8	20.1	16.3
Outer Cape Cod	7.8	17.9	13.5	11.7	18.6	22.8	11.0	16.9	17.1	20.7	14.3	17.1	20.2	21.3	21.8	15.7
Buzzards Bay	12.7	15.2	12.2	12.4	13.3	14.9	15.0	16.2	12.6	13.9	14.5	18.3	21.0	24.2	25.6	16.4

Table 18. Percent trap mortality by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
State	0.15	0.04	0.22	0.15	0.18	0.20	0.10	0.15	0.12	0.17	0.37	0.08	0.13	0.22	0.21	0.18
Cape Ann	0.00	0.00	0.09	0.27	0.03	0.16	0.00	0.03	0.13	0.09	0.48	0.10	0.11	0.14	0.28	0.17
Beverly-Salem	0.00	0.00	0.00	0.00	0.04	0.22	0.03	0.19	0.14	0.29	0.41	0.13	0.19	0.13	0.74	0.49
Boston Harbor	---	---	---	0.00	0.03	0.03	0.23	0.09	0.03	0.04	0.01	0.03	0.06	0.04	0.01	0.04
Cape Cod Bay	0.00	0.02	0.03	0.00	0.00	0.02	0.15	0.00	0.02	0.05	0.02	0.02	0.02	0.00	0.03	0.03
Outer Cape Cod	0.46	0.22	0.23	0.48	0.40	0.85	0.27	0.66	0.47	0.62	0.35	0.24	0.30	0.58	0.38	0.43
Buzzards Bay	0.62	0.00	1.13	0.43	0.76	0.25	0.01	0.18	0.11	0.18	1.74	0.10	0.29	0.71	0.16	0.21